INDOOR AIR QUALITY ASSESSMENT

Department of Employment and Training
Route 114-Stadium Plaza
Lawrence, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of building occupants, the Bureau of Environmental Health Assessment (BEHA) conducted an evaluation of the indoor air quality at the Department of Employment and Training (DET) located on Route 114, Stadium Plaza, Lawrence, MA. On April 11, 2003, a visit was made to this building by Cory Holmes, Environmental Analyst of our Emergency Response/Indoor Air Quality (ER/IAQ) to conduct the assessment. Mr. Holmes was accompanied by Ronald Dobrowski and Edward Galante of the DET's Facilities Management department as well as Chris Colbert, employee representative of the Lawrence DET. Concerns about symptoms potentially related to poor indoor air quality prompted the request.

The DET leases office space in a one-story strip mall that was reportedly a former gym. The interior of the building was converted to office space around 1993. DET staff have occupied the building for approximately ten years. The building has a flat, rubber membrane roof and windows are openable throughout the DET office area. The DET area is made up of small offices, storage rooms, file areas and an open floor plan containing cubicles with cloth dividers.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor Model 8551. Screening for total volatile organic compounds (TVOCs) was conducted in the vocational education wing using a Thermo Environmental, Inc. Photo Ionization Detector (PID). Outdoor background TVOC measurements were taken for comparison to indoor levels. Moisture content in

gypsum wallboard (GW) and wood was measured with a Delmhorst, BD-2000 Model, Moisture Detector with a Delmhorst Standard Probe.

Results

The DET has a staff population of approximately 70-80 and functions as a call center only with no public access. The tests were taken during normal operations. Test results appear in Tables 1-3.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 ppm in all occupied areas surveyed, indicating inadequate air exchange. Mechanical ventilation is provided by rooftop air handling units (AHUs) (see Picture 1). Fresh air drawn into outside air intakes and is distributed via ductwork connected to ceiling mounted air diffusers (see Picture 2). Exhaust ventilation is provided by ceiling-mounted exhaust grills that are ducted back to AHUs (see Picture 3).

Thermostats control each heating, ventilating and air conditioning (HVAC) system. These thermostats have fan settings of "on" and "automatic". Thermostats were set to the "automatic" setting in most of the areas surveyed during the assessment. The automatic setting on the thermostat activates the HVAC system at a preset temperature. Once a preset temperature is measured by the thermostat, the HVAC system is deactivated. Therefore no mechanical ventilation is provided until the thermostat re-activates the system. Without dilution and removal by the mechanical ventilation system,

commonly occurring indoor air pollutants can build up and lead to indoor air quality/comfort complaints.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air

(ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix I.

Temperature measurements ranged from 67° F to 76° F, which were below the BEHA recommended comfort range in some areas. The BEHA recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Temperature control/comfort complaints were expressed by staff in a number of areas. In some cases thermostats were observed near office equipment such as photocopiers (see Picture 4). Heated air rising from the photocopier could influence the thermostat, which could in turn activate the HVAC system to provide cold air to this area during summer months. In winter, the HVAC system would be deactivated by heated air from the photocopier interacting with the sensors in the thermostat. A large output photocopier was located in a semi-enclosed area that also houses two employees (see Tables). No local exhaust ventilation is located in this area to remove excess heat generated by the photocopier. The close proximity of the

photocopiers to thermostats, in combination with occupants, makes it difficult for the ventilation system to control for comfort.

Cold complaints were expressed in the Hatfield cubicle area. A 1-1 ½ inch space was noted between the door bottom and the threshold that leads to an exterior hallway, which can provide a means for cold air to penetrate into the DET. The exterior hallway is not heated. The temperature of the hallway was 7^{o} F to 11^{o} F lower than the occupied DET area.

The relative humidity measured in the building ranged from 27 to 40 percent, which was below the BEHA recommended comfort range in most areas. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Visible mold growth was noted on the gypsum wallboard (GW) in the storeroom near the floor (see Picture 5). Also noted were water stains on cardboard boxes stored on the floor (see Picture 6), which indicates historic water penetration/flooding. DET staff could not recall any water issues/flooding in recent memory. No obvious interior sources of moisture were seen during the assessment. BEHA staff observed conditions along the outside perimeter of the building adjacent to this area to identify breaches in the building envelope, which could provide a source of water penetration. No exterior sources were

identified. DET staff stated that the building's gutter/drainage system was improved over the past year, which likely eliminated this potential source of water penetration.

Like other porous materials, if GW becomes wet repeatedly it can provide a medium for mold growth. Mold and related particulates can be irritating to sensitive individuals. In order for building materials to support mold growth, a source of water is necessary. Identification and elimination of water moistening building materials is necessary to control mold growth. GW with increased moisture content over normal concentrations may indicate the possible presence of mold growth. Identification of the location of GW with increased moisture levels can also provide clues concerning the source of water supporting mold growth. In an effort to ascertain moisture content of GW, samples were taken in areas most likely impacted by water damage, primarily the at the base of the wall where mold growth was present (see Picture 5), as well as a number of non-effected areas for comparison. As discussed, water content of GW was measured with a Delmhorst, BD-2000 Model, Moisture Detector with a Delmhorst Standard Probe. The probe was inserted into the surface of GW on walls. The Delmhorst probe is equipped with three lights as visual aids to determine moisture level. Readings, which activate the green light, indicate a sufficiently dry level (0 - 0.5%), those that activate the yellow light indicate borderline conditions (0.5 – 1.0%) and those that activate the red light indicate elevated moisture content (> 1%).

A number of moisture measurements were taken of GW. No elevated moisture measurements were recorded. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials (e.g. GW and carpeting) be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If porous

materials are not dried within this time frame, mold growth may occur. Once mold growth has occurred, disinfection of these materials may be possible, however since GW is a porous surface, disinfection is likely to be ineffective.

On previous assessments concerning GW mold growth, BEHA personnel have consulted with Dr. Harriet Burge, Chairperson of the Microbiology Department at the Harvard School of Public Health. The reoccurrence of mold growth on GW after the application of bleach is common. Bleach consists of sodium hypochlorite in a 5 percent concentration mixed with water. Mold colonization of GW can penetrate through its entire structure. When applied to moldy GW, the water of the bleach solution penetrates into the moldy GW, but the sodium hypochlorite remains on the surface. The sodium hypochlorite disinfects the surface mold that it comes in contact with on the GW surface, but not the mold beneath the surface. The additional water added to the subsurface mold fuels a spurt in growth, which increases mold colonization of the GW. As a result, mold colonies appear on the surface of treated GW shortly after application of bleach (Burge, 1999).

Water damage was noted around a windowsill that occupants reported was due to a breach in the exterior wall (see Pictures 7 & 8). BEHA staff conducted moisture readings of the GW and found no elevated moisture content. Also observed in this area was water damage related to plants being placed on the wooden windowsill (see Picture 9). BEHA staff measured moisture content of the wood and found it to be saturated. As stated, porous materials can provide a medium for microbial growth if wetted repeatedly.

A number of areas had water coolers and/or water fountains installed over carpeting. Water spillage or overflow of cooler catch basins can result in the wetting of

the carpet. A personal humidifier was observed that had residue/build-up in the reservoir. These reservoirs are designed to catch excess water during operation and should be emptied/cleaned regularly to prevent microbial and/or bacterial growth.

Other Concerns

A number of other conditions were noted during the assessment, which can affect indoor air quality. A mechanical room adjacent to the DET office area houses a sewerage pumping station. The contour of the land where the DET is located requires the facility to mechanically pump sewerage up gradient to the city system. Complaints of periodic odors were reported in the DET. The mechanical room and the DET area share an adjoining wall. Pipes and wiring were observed traversing the wall between the DET and the mechanical room (see Picture 10). In addition, the metal door to the mechanical room was severely corroded at the bottom (see Picture 11). Under certain wind and weather conditions, the mechanical room can become pressurized. The damaged door to the mechanical room, and holes in ceilings and walls are breaches that can serve as a source and means of egress for odors, fumes, dusts and vapors between the mechanical room and the DET. The mechanical room is equipped with a ceiling mounted exhaust fan. Building maintenance staff should ensure that the fan is operable at all times to draw air away from occupied areas of the DET.

Other pathways for odors/drafts to migrate into occupied areas were observed, including spaces under exterior hallway doors, missing ceiling tiles and a large wall crack in the Hatfield cubicle area (see Picture 12). These breaches can all serve as a means of egress for odors, fumes, dusts and vapors between areas.

DET staff raised concerns over residual fumes and lingering odors from a computer battery that reportedly over loaded several months prior to the BEHA assessment. No lingering detectable odors or measurable TVOCs above background were noted by BEHA staff or were reported during the assessment. The presence of residual materials seems unlikely since a significant amount of time has passed since the incident, as well as the operation of the buildings ventilation systems, which would dilute and remove lingering odors.

Building occupants reported on-going complaints of eye irritations. There are a number of conditions that can contribute to this complaint. Accumulation of dust on flat surfaces was noted. Dust can be irritating to the eyes, nose and respiratory tract. The large amount of items stored provides a means for dusts, dirt and other potential respiratory irritants to accumulate. These stored items, (e.g. papers, folders, boxes) make it difficult for custodial staff to clean. A number of exhaust and return vents were also noted with accumulated dust (see Picture 13). If exhaust vents are not functioning, back drafting can occur, which can re-aerosolize dust particles.

As discussed, several areas contain photocopiers. VOCs and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, D., 1992). Photocopiers should be located near local exhaust ventilation.

An air purifier was seen in one occupant's cubicle. These units are normally equipped with filters, which should be cleaned or changed as per the manufacturer's instructions to avoid the build-up and re-aerosolization of dirt, dust and particulate matter.

Mechanical exhaust ventilation was not functioning in several restrooms during the assessment. Exhaust ventilation is necessary in restrooms to remove moisture and to prevent restroom odors from penetrating into adjacent areas.

Lastly, DET staff frequently use VOC-containing cleaning materials (see Picture 14) to clean their personal work areas. This material contains several VOCs (e.g. isopropyl alcohol and monoethanolamine) that can be irritating to the eyes, nose and throat (3M, 2000) (see Picture 14).

Conclusions/Recommendations

In view of the findings at the time of the visits, the following **short-term** recommendations are made:

1. Remove and replace any mold contaminated/water damaged GW. This measure will remove actively growing mold colonies that may be present. Remove mold contaminated materials in a manner consistent with recommendations found in "Mold Remediation in Schools and Commercial Buildings" published by the US Environmental Protection Agency, Office of Air and Radiation, Indoor Environments Division, Washington, DC. EPA 402-K-01-001. March 2001. Copies of this document can be downloaded from the US EPA website at: http://www.epa.gov/iaq/molds/mold_remediation.html. Removing the water-damaged gypsum wallboard will also give maintenance personnel the opportunity to observe conditions within the wall cavity and to determine any signs of water penetration through breaches of the building envelope.

2. Ensure the exhaust fan for the mechanical room is operating to draw odors away from the DET.
3. Seal wall crack shown in Picture 12.
4. Repair/replace restroom exhaust motors.
5. To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of building occupancy independent of thermostat control. Set thermostats to fan "on" position to provide a constant source of ventilation.
6. In order to improve indoor air quality, an increase in the percentage of fresh air supply into the HVAC system may be necessary. Consult with a ventilation engineer to determine methods to increase fresh air intake.
7. Ventilation industrial standards recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994). Consult a ventilation engineer concerning re-balancing of the ventilation systems.
8. Clean/change filters for air-handling equipment as per the manufacturer's instructions or more frequently if needed. Vacuum interior of units prior to activation to prevent the aerosolization of dirt, dust and particulates.
9. Relocate photocopiers and other heat generating office equipment from the vicinity of thermostats (and occupants if possible).
10. Install a door sweep beneath the hallway door in the Hatfield cubicle area to prevent drafts and heat loss.
11. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, implementation of scrupulous cleaning

practices should be implemented. This will minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. Use of vacuum cleaning equipment outfitted with a high efficiency particulate arrestance (HEPA) filter is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

12. A coordinated effort between, DET management, staff and building management and maintenance personnel should be made to conduct cleaning of offices, common areas and cubicles/ personnel work spaces to prevent the accumulation of settled dust.
13. Repair any water leaks and replace any water damaged building materials (e.g. ceiling tile, GW). Examine the areas above and behind these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
14. Ensure all plants are equipped with drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.
15. Relocate or place tile or rubber matting underneath water coolers in carpeted areas.
16. Keep windows closed during hot, humid weather to maintain indoor temperatures and to avoid condensation problems.
17. Clean/change filters for portable air purifier as per the manufacture's instructions or more frequently if needed.

18. Seal all utility holes and openings in the mechanical (sewer pump) room as well as in the common wall shared with the DET to eliminate pathways for movement of odors into occupied areas.

19. Clean and maintain humidifiers/dehumidifiers as per the manufactures instructions.

20. Discontinue the use of VOC-containing cleaners. Less irritating materials (e.g. soap and water) may suffice to clean occupant areas.

21. For further building-wide evaluations and advice on maintaining public buildings, see the resource manual and other related indoor air quality documents located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

References

BOCA. 1993. The BOCA National Mechanical Code-1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL. M-1601 et al.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

Schmidt Etkin, D. 1992. Office Furnishings/Equipment & IAQ Health Impacts, Prevention & Mitigation. Cutter Information Corporation, Indoor Air Quality Update, Arlington, MA.

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

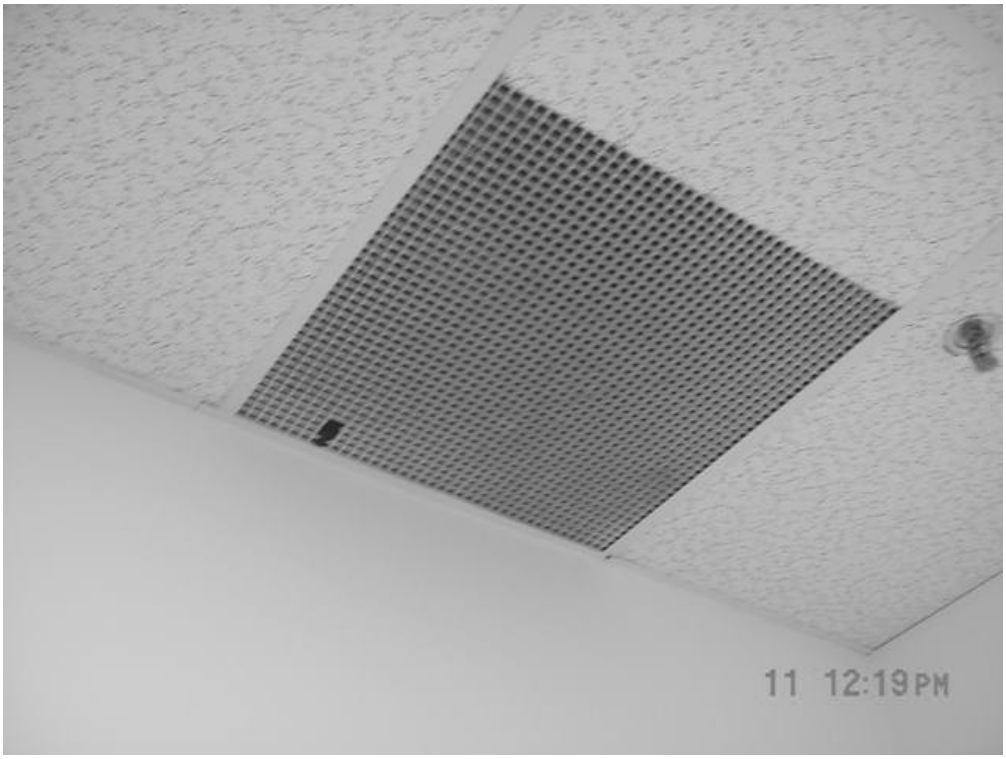
Picture 1

Rooftop Air Handling Units

Picture 2

Fresh Air Supply Diffuser

Picture 3



Ceiling-mounted Exhaust Grill

Picture 4

Thermostat

Thermostat on Wall near Photocopier

Picture 5

Mold Growth (Dark Staining) on Gypsum Wallboard in Storage Room

Picture 6

Water Damaged Cardboard Box in Storage Area

Picture 7

Water Damaged GW Over Window

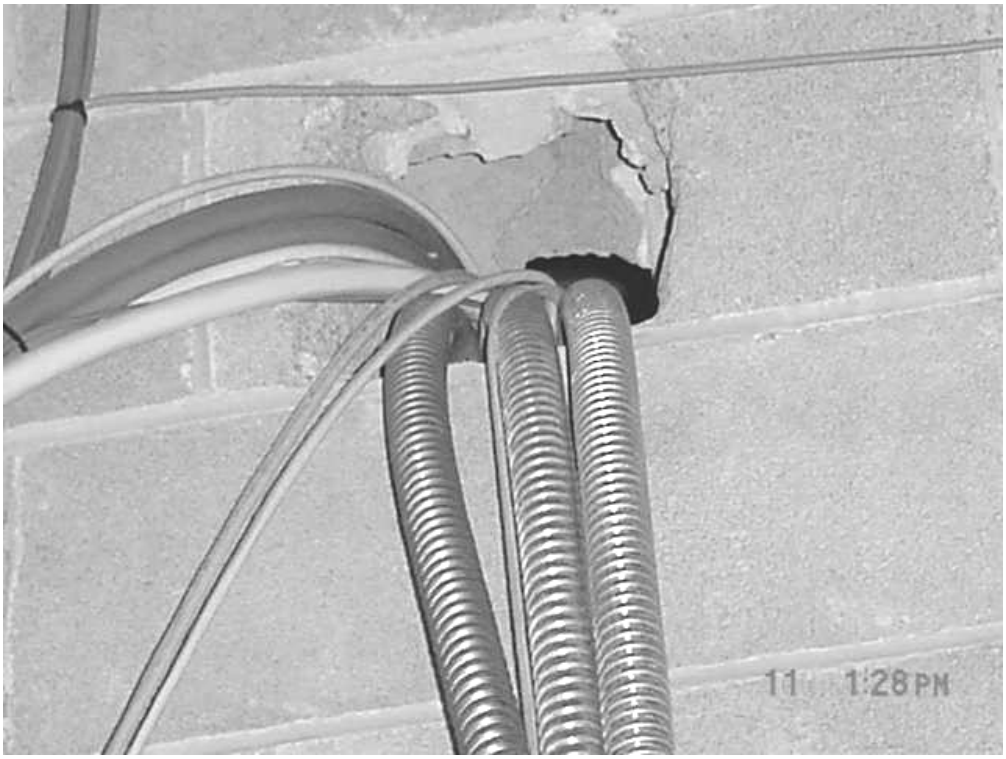
Picture 8

Damaged Exterior Brickwork Associated with Water Damage Near Window in Picture 7

Picture 9

Water Damaged Wooden Windowsill Beneath Plants

Picture 10



Utility Hole in Wall of Mechanical Room Leading into the DET

Picture 11

Corroded Metal Door to the Mechanical Room

Picture 12

Large Wall Crack in Hatfield Cubicle Area

Picture 13

Accumulated Dust on Exhaust Vent

Picture 14

Spray Cleaner Used in the DET, Note Label Says May Cause Eye Irritation

TABLE 1

Indoor Air Test Results – Division of Employment and Training – Lawrence, MA April 11, 2003

Location	Carbon Dioxide (*ppm)	TVOCs (*ppm)	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
							Supply	Exhaust	
Outside (Background)	412	0.0	49	41					Cold, overcast, wind 10-13mph
Director's Office	1940	0	71	40	7	N	Y	N	3 CT
Niven	1329	0	71	33	5	Y	Y	N	Air purifier, feather duster, 1 CT
Cleary	1331	0	71	32	1	N	Y	N	Exhaust in door, 1 CT, plants – signs of mold growth on plant basket, spray cleaner, eye irritant
Caron	1243	0	70	32	3	Y	Y	Y	
Colbert	1480	0	72	32	2	N	Y	Y	Photocopier & computer equipment near thermostat
Bond	1297	0	73	31	1	N	Y	N	2 CT
Computer Room	1294	0.0	77	30	0	N	Y	N	1 CT, mainframe
Keefe	1211	0	75	27	5	N	Y	Y	Plants paper water-damaged under plant
Douglas	1060	0	67	30	4	Y	Y	Y	Water-damaged GW around window, moisture readings 0.0 (dry), plants on wooden

*** ppm = parts per million parts of air**
UV = Univent
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

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							Supply	Exhaust	
									windowsill saturated (2.2)
Vanes	1204	0.0	69	34	4	Y	Y	Y	
Men's Rest Room				34	0	N	Y	Y	1 MT, 1 CT exhaust not operating
Kiley	1329	0.0	72	33	4	N	Y	Y	Damaged CT
Women's Rest Room				33	0	N	Y	Y	Exhaust vent not operating
Mirabelle	1272		76	30	5	N	Y	Y	
Lansford	1238	0.0-0.2	76	28	2	N	Y	N	Large photocopier, No return/exhaust vent
Hatfield	830		67	29	3	N	Y	Y	Reports of odors/draft in area/humidifier
Hallway Outside Hatfield Area	460		60	25					Spaces around door
Mitsios	968		71	32	2	N	Y	Y	1 CT 2 laser jet printers
Berry	989		72	32	1	N	Y	N	

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							Supply	Exhaust	
Costin	1000		72	31	3	N	Y	Y	Photocopier
Hallway Outside Rest Rooms									Holes in wall
Women's Rest Room							Y	Y	Noisy fan in women's rest room 2 CT, exhaust tied to light switch
Mail Room	958		71	28	0	N	Y	Y	1 CT accumulated dust on exhaust vent
Supply Room	986		71	29	0	N	Y	Y	1 CT, possible mold growth on GW around base of wall, cardboard boxes water-damaged, Moisture readings 0.0 (dry)
Mechanical/Sewage Pump Room								Y	Odors, utility holes in wall, bottom of door corroded, local exhaust fan in ceiling/roof

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